WATER QUALITY MONITORING IN LAS VEGAS WASH: LAKE LAS VEGAS PROJECT 1994

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I. PROJECT BACKGROUND

Lake Las Vegas was conceived in 1964 by J. Carlton Adair, then President of the Port Holiday Authority. The 2243 acre development project was known as Port Holiday, and the lake was called "Lake Adair." Project land was acquired from the federal government under a land exchange act (PL 88-639) authorized by Congress on October 8, 1964. Approximately 170 acres of privately owned land in the Lake Mead National Recreation Area (LMNRA) was exchanged for 2243 acres in Las Vegas Wash (LVW). That property was located along the western border of the LMNRA in Las Vegas Wash (Figure 1).

Carlton Adair halted the project in 1971, though a considerable amount of engineering and feasibility work had been done. The project remained idle until 1982 when it was reinitiated as the Lake at Las Vegas Project by Barry Silverton and the Pacific Malibu Development Corporation of Los Angeles, CA. Pacific Malibu and its prime consultant J.M. Montgomery (JMM) Consulting Engineers conducted extensive engineering and environmental studies during 1984-1987. Transcontinental Properties (TCP) of Scottsdale, AZ, acquired controlling interest in the project in 1988. TCP and its consultants completed the engineering and environmental studies and obtained the necessary local, state, and federal permits required to start construction of the project. Construction was started on April 1, 1989. The project is now called Lake Las Vegas Joint Venture.

II. PROJECT DESCRIPTION

Lake Las Vegas ultimately will consist of six hotels, five golf courses, 3,500-5,000 dwelling units, condominium developments, and commercial and civic developments. At full development, it will have an estimated permanent population of 12,500 people and a tourist population of 32,500.

The focal point of the project will be the 320 acre recreational lake. The lake is being filled behind a 4800 ft. zoned, S-shaped embankment dam, 1500 ft. upstream of North Shore Road. The 190 ft. high dam was constructed with 3.0 million cubic yards of locally available materials. The lake will be maintained at 1403 ft. above MSL. At that level, it will have a capacity of 10,000 acre feet, 320 surface acres, a two mile length, a one mile width and 12.3 miles of shoreline.

The lake is being filled with water drawn from Lake Mead. About 7,000 acre feet will be required annually for project irrigation, seepage and evaporative losses from the lake.

LVW wastewaters are by-passed under the lake through twin 84 inch diameter pipelines. The bypass system is 9,450 ft. in length and designed to pass flows up to 1760 CFS. Flows currently average about 220 CFS in LVW.

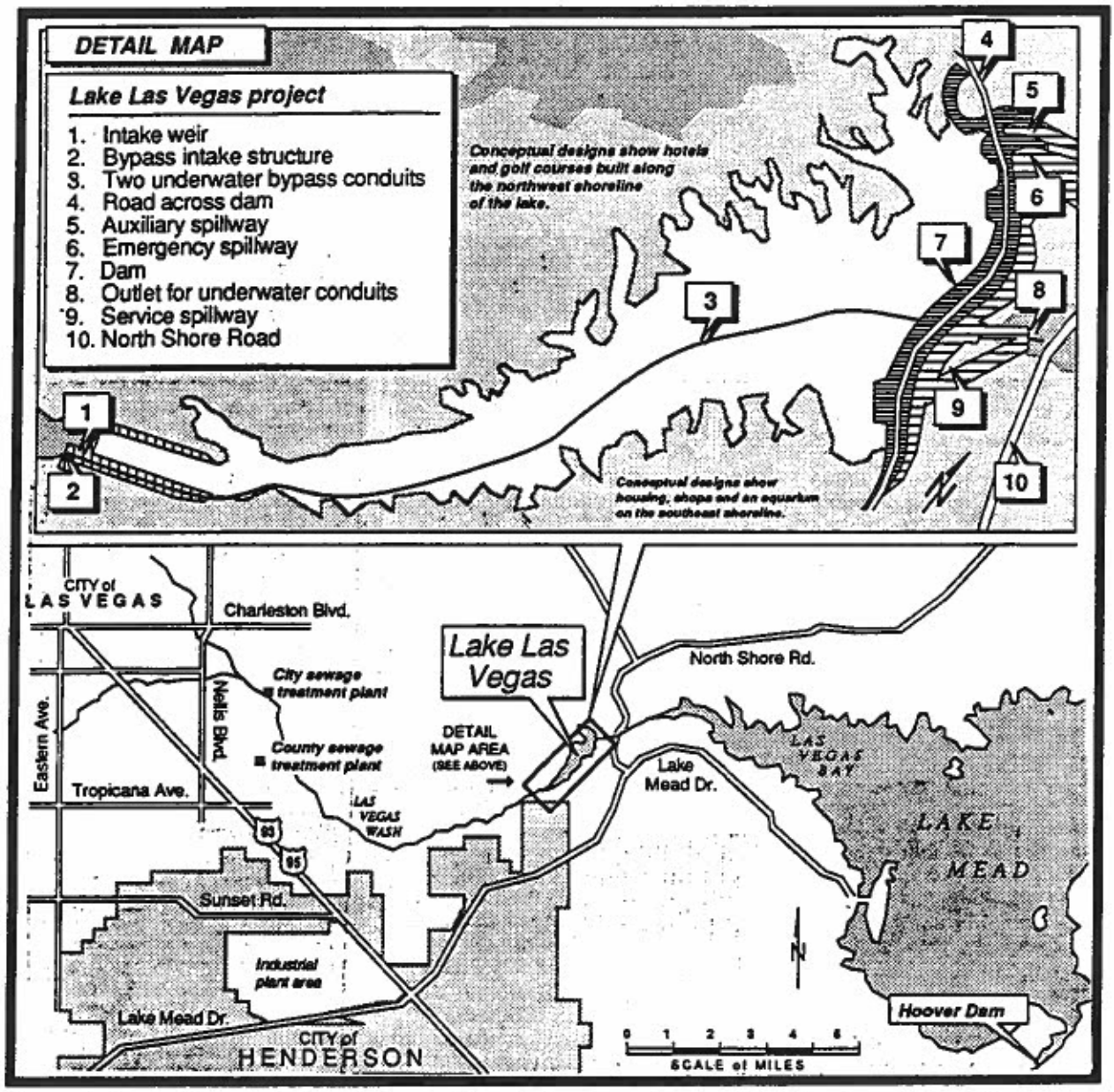

Figure 1. Location and description of the Lake Las Vegas Joint Venture (Las Vegas Review Journal map by Jim Day July 28, 1991).

III. WATER QUALITY HISTORY

Water quality in Lake Las Vegas itself and potential effects of the project on waters in LVW and Lake Mead have been major concerns since the project's inception in 1964. A water quality assessment was first made in 1968 as part of the engineering feasibility studies that were conducted by Tipton and Kalmback, Inc., Engineers of Denver, CO. Extensive water quality studies have been conducted since 1984 when the project was reintiated by Pacific Malibu Development Corporation, Los Angeles, CA. The following chronology is a summary of those studies and other water quality related activities.

A. Chronology of Lake Las Vegas Water Quality Activities

Date	Activities
Mar. 7, 1984	Pacific Malibu Development Corporation applies for a 404 permit (#8562) to the U.S. Army Corps of Engineers (USACE) to place fill material in LVW during construction of a dam and appurtenant works.
Mar. 16, 1984	James M. Montgomery (JMM) Consulting Engineers, consultant for Pacific Malibu, requests water quality certification for LLV from the Nevada Division of Environmental Protection (NDEP).
May 16, 1984	NDEP administrator, L.H. Dodgion recommends that a water quality assessment be done for LLV, including analysis of impacts in LVW and Lake Mead.
May 1984	JMM issues a 19 page report about general water quality impacts of LLV.
June 24, 1984	NDEP issues water quality certification for LLV under Section 404 of the Clean Water Act.
June 29, 1984	JMM prepares an Environmental Assessment for LLV.
Aug. 7, 1984	USACE holds a public hearing in Henderson, NV on the 404 permit (#8562) request from Pacific Malibu.
Sept. 19, 1984	U.S. Environmental Protection Agency (EPA) expresses written concern to USACE about potential water quality impacts of LLV on LVW and Lake Mead.
Nov. 1984	JMM issues a 9 page report entitled: "Water Quality Impact Analysis for Lake at Las Vegas."
Nov. 23, 1984	USACE issues a conditional 404 permit (#8562) for LLV. Special condition b.(4) requires that Pacific Malibu, ----"develop a detailed plan for water quality monitoring and operation and maintenance of the lake." Special condition c. requires that Pacific Malibu comply with the Clark County 208 Water Quality Management Plan.
April 1985	JMM prepares a draft, "Water Quality Criteria and Operations and Maintenance Plan for Lake at Las Vegas" report.
May 1985	JMM revises the draft, "Water Quality Criteria and Operations and Maintenance Plan for Lake at Las Vegas" report.
July 10, 1985	USACE accepts JMM water quality management plan and signs off on Special Condition b.(4) of permit application #8562.

Dec. 14, 1987	USACE extends permit application #8562 to December 31, 1989 provided the developer satisfies provisions of Clark County 208 Plan by June 30, 1988.
Feb. 25, 1988	JMM revises water quality plan to include an evaluation of impacts associated with urban and stormwater runoff.
Mar. 24, 1988	JMM issues a 18 page report entitled, "Lake at Las Vegas Project Water Quality Management Plan."
Mar. 28, 1988	City of Henderson and Transcontinental Properties (TCP), the new joint project owners, request an amendment to the Clark County 208 Plan for the LLV.
Apr. 4, 1988	JMM issues revised "Lake at Las Vegas Project Water Quality Management Plan."
Apr. 5, 1988	Board of Clark County Commissioners conditionally approves the Clark County 208 Plan amendment for LLV. One condition requires that a water quality monitoring and maintenance plan be enforced for LLV. Another requires that a variance be granted by the Clark County Regional Flood Control District (CCRFCD).
Aug. 11, 1988	USACE requests public comment on the amended 404 permit application #8562A for LLV.
Nov. 22, 1988	Dr. Larry J. Paulson develops a, "Water Quality Monitoring Program: Lake at Las Vegas Project" at the request of TCP.
Dec. 2, 1988	Harza Engineers completes its draft technical review of LLV for the CCRFCD.
Dec. 1988	TCP and its consultants respond to Harza Engineers' draft report.
Jan. 5, 1989	Harza Engineers issues its final technical review of LLV.
Jan. 12, 1989	CCRFCD denies the flood control variance for LLV.
Mar. 1, 1989	TCP contracts with Dr. Larry Paulson and the Lake Mead Limnological Research Center, UNLV, for a five month water quality monitoring program in LVW (March 1 - July 31, 1989).
Mar. 10, 1989	CCRFCD approves flood control variance for LLV.
Mar. 12, 1989	TCP and its contractor, Washington Construction Co. (WCC), begin construction on the dam abutment outside 100 year flood plain.
Mar. 13, 1989	Water quality sampling program begins in LVW.
Mar. 30, 1989	USACE issues 404 permit #8562A for LLV.
Apr. 1, 1989	TCP and WCC start construction on bypass pipeline and diversion inlet structure for LLV.
Aug. 9, 1989	Flood occurs in Las Vegas Wash.
Aug. 21, 1989	Saline spring surfaces in trench of bypass pipeline.
Jan. 1, 1990	TCP contracts with Dr. Larry J. Paulson and his firm West Lakes for water quality monitoring in Las Vegas Wash.
Jan. 19, 1990	Flood occurs in Las Vegas Wash.
Feb. 15, 1990	Bypass pipeline and diversion inlet structure completed.
Feb. 16, 1990	Las Vegas Wash flows diverted into bypass pipeline.
Feb. 17, 1990	WCC starts work on earthen dam.
March 7, 1990	Saline spring surfaces mid-way through reservoir site, forming a small lake upstream of coffer dam.

Apr. 1, 1990	Dr. Larry J. Paulson publishes technical report on results of water quality monitoring in Las Vegas Wash during 1989.
June 11, 1990	Large flood occurs in Las Vegas Wash. Flows were estimated at 3400 CFS and over-topped the intake structure, spilling about 700 acre feet of stormwaters into the LLV reservoir site.
July 16, 1990	Another large flood occurs in Las Vegas Wash.
Oct. 1990	WCC starts work on water inlet pipeline for LLV.
Dec. 26, 1990	Water inlet pipeline completed. TCP starts filling the LLV reservoir at about 800 GPM. Inlet waters combine with saline spring waters to increase size of lake above coffer dam.
Jan. 1, 1991	TCP contracts with Dr. Larry J. Paulson and his firm West Lakes for water quality monitoring in Las Vegas Wash and LLV reservoir.
Feb. 28, 1991	Moderate flood occurs in Las Vegas Wash.
March 1, 1991	Moderate flood occurs in Las Vegas Wash.
March 28, 1991	Large flood occurs in Las Vegas Wash. Stormwaters over-topped the intake structure and spilled into the LLV reservoir site.
May 25, 1991	Water inlet flows increased to 5600 GPM to accelerate filling of LLV reservoir.
June 24, 1991	Intensive water quality monitoring program started in LLV reservoir by Dr. Larry Paulson and his firm West Lakes.
June 27, 1991	WCC completes construction of sediment basin in Las Vegas Wash just upstream of intake structure.
July 1, 1991	Saline spring waters mix with inlet waters and flow into reservoir site.
August 20, 1991	WCC completes construction of LLV dam. Dam approved by Nevada State Engineer's office.
Aug.-Sept. 1991	Inflowing waters cause substantial erosion of alluvial deposits in the old Las Vegas Wash channel.
Aug.-Nov. 1991	Higher than expected algal growth occurs in LLV reservoir due to phosphorus inputs from spring waters and erosion of alluvial deposits.
Dec. 4, 1991	Water levels reach 1367 feet, 37 feet below the normal operating level of 1403 feet.
Dec. 31, 1991	Water levels reach 1370 feet, 33 feet below the normal operating level of 1403 feet.
Jan. 6, 1992	Flood occurs in Las Vegas Wash, over-tops the intake structure and spills 48 acre feet of stormwater into LLV.
Feb. 13, 1992	Flood occurs in Las Vegas Wash, over-tops the intake structure and spills 472 acre feet of stormwater into LLV.
Feb. 14, 1992	Water levels reach 1378 feet, 25 feet below the normal operating level of 1403 feet.
March 5, 1992	Dr. Larry J. Paulson publishes technical report on results of water quality monitoring in Las Vegas Wash during 1991.
March 8, 1992	Flood occurs in Las Vegas Wash, over-tops the intake structure and spills 569 acre feet of stormwater into LLV. Water levels reach 1381.3 feet in LLV.
March 23, 1992	Dr. Larry J. Paulson publishes technical report on results of water quality monitoring in LLV during 1991.
March 24, 1992	Moderate open water algae bloom occurs in LLV as a result of nutrient inputs from stormwater spills.

March 27, 1992	Flood occurs in Las Vegas Wash, over-tops the intake structure and spills 1087 acre feet of stormwater into LLV. Water levels reach 1387.9 feet in LLV.
March 28, 1992	Flood occurs in Las Vegas Wash, over-tops the intake structure and spills 109 acre feet of stormwater into LLV.
March 30, 1992	Flood occurs in Las Vegas Wash, over-tops the intake structure and spills 470 acre feet of stormwater into LLV.
March 31, 1992	Flood occurs in Las Vegas Wash, over-tops the intake structure and spills 603 acre feet of stormwater into LLV. Water levels reach 1391.5 feet in LLV.
April 7, 1992	Another moderate open water algae bloom occurs in LLV as a result of nutrient inputs from late March stormwater spills.
April-May 1992	Zooplankton explode in LLV and graze open water algae. Transparency increases to nearly 30 feet in lower end of the lake. Attached algae bloom occurs on rip-rap and underwater debris.
May-June 1992	Crayfish population in LLV augmented by stocking in an effort to control growth of attached algae.
July 7, 1992	Bluegreen algae bloom occurs in upper LLV due to nutrient inputs from springs.
Oct. 25, 1992	Flood occurs in Las Vegas Wash, over-tops the intake structure and spills 330 acre feet of stormwater into LLV.
Jan. 19, 1993	Moderate flood occurs in Las Vegas Wash.
Feb 8-9, 1993	Flood occurs in Las Vegas Wash, over-tops the intake structure and spills 1785 acre feet of stormwater into LLV. Water levels reach 1399.5 feet in LLV
Nov. 30, 1993	A total of 3,300 catchable rainbow trout stocked in LLV
March 19, 1994	A total of 50,000 fathead minnows, 20,000 channel catfish and 1,000 goldfish stocked in LLV.
Aug. 8-9, 1994	Moderate flood occurs in LVW.
Aug.,11, 1994	Sediment basin in LVW just uplake of LLV upgraded and lined with concrete.
Dec, 9, 1994	Another 5,200 catchable rainbow trout and 1,000 fingerling rainbow trout stocked in LLV

IV. WATER QUALITY MONITORING PROGRAM

The revised Clark County 208 Water Management Plan approved by the Clark County Board of County Commissioners on April 5, 1988 and certified by the State of Nevada on August 8, 1988 required that a water quality monitoring program be developed for Lake Las Vegas. The monitoring is required to insure that water quality standards are not being violated by construction activities and operations of the reservoir. The water quality monitoring program was developed on November 22, 1988. Water quality sampling was started in LVW on March 13, 1989. Results of water quality monitoring during 1989 were presented in Paulson et al. (1990); for 1990 in Paulson et al. (1991); for 1991 in Paulson et al. (1992a); for 1992 in Paulson et al. (1993a); and for 1993 in Paulson et al. (1994a).

A. Las Vegas Wash Sampling Locations

Two permanent sampling stations were established in LVW upstream (LVW-A) and downstream (LVW-B) of the project in 1989. Station LVW-A is located at the southwestern end of the project property line just upstream from the diversion inlet structure (Figure 2). Both stream banks were graded in 1990 to make way for construction of the bypass pipeline intake structure. The stream is about 4 m wide at this station and confined to a narrow, relatively deep channel. A earth/rock S-shaped berm was constructed just below LVW-A, upstream of the intake structure in June 1991 to reduce sediment loads in Las Vegas Wash. The berm was upgraded in August 1994 when a part of the channel was lined with concrete to facilitate removal of sediment deposits.

Station LVW-B was located below the North Shore (Lake Shore) Road bridge, about 500 m downstream of the dam site during monitoring in 1989 through June 17, 1991 (Figure 2). Water quality at this station also is monitored periodically by the U.S. Geological Survey and City of Las Vegas Water Pollution Control Facility/Clark County Sanitation District/City of Henderson. That area has been subject to extensive erosion

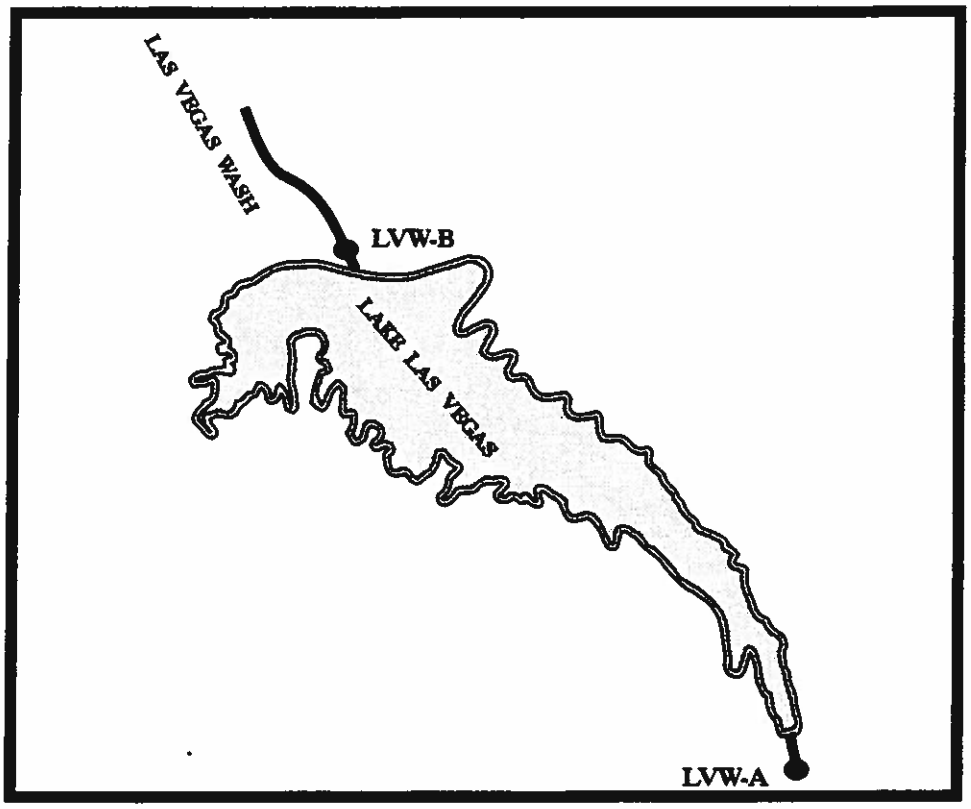

Figure 2. Locations of water quality monitoring stations in Las Vegas Wash.

since 1975 and is now channelized, with a stream channel about 12 m in width. The vegetation consists of salt cedar on the north side and a mix of salt cedar, cattails and terrestrial vegetation on the south side. Station LVW-B was moved to just below the LLV dam on June 24, 1991. Sampling has continued to date at that location.

Water quality sampling was conducted at these stations monthly during January, February, November, and December; biweekly during March and October; and weekly during April to September of 1994.

B. Field Measurements

Temperature, pH, dissolved oxygen, and specific conductance were measured at each station with a Hydrolab Surveyor Model III Water Quality Analyzer (Table 1). Measurements were made on grab samples collected near mid-channel at a depth just below the surface.

C. Chemical and Biological Analyses

Grab samples were collected from mid-channel just below the surface at both stations. Samples requiring filtration were filtered through 0.45 micron Millipore filters. Measurements and analyses were run on about 10% duplicate grab samples collected at LVW-A. About 10 % of the samples collected at LVW-B were diluted in half with deionized water (later referred to as half-dilutions) to evaluate accuracy of the chemical and biological analyses.

V. WATER QUALITY MONITORING RESULTS

A. Quality Control

There were minor differences (< 2.0%) between duplicate field measurements of temperature, dissolved oxygen, pH, and conductance made in Las Vegas Wash during 1994 (Table 2). There were also minor differences between field duplicates for most chemical and biological analyses. However, there was a 24% difference between field duplicates for total suspended solids and 77.1% difference for fecal coliforms (Table 2), reflecting the higher variability in those analyses.

Chemical and biological analyses of half-dilution samples collected in Las Vegas Wash downstream (LVW-B) of Lake Las Vegas all fell within 5% of the 50% expected value (Table 3).

Table 1. Physical measurements and chemical and biological analyses made at sampling stations in Las Vegas Wash.

	Sampling Program		
Measurements	Depth(s)	Frequency	Method(s)
Physical			
Temperature(°C)	0 m	See Text	Leavitt et al. (1990)
Dissolved Oxygen (mg/l)	0 m	"	"
pH (Std. Units)	0 m	"	"
Conductivity (µmhos/cm)	0 m	"	"
Turbidity (NTU)	0 m	"	"
Chemical			
Total Kjeldahl Nitrogen (mg/l)	0 m	"	APHA (1989)
Ammonia-N (mg/l)	0 m	"	Leavitt et al.
Nitrite+Nitrate-N (mg/l)	0 m	"	(1990)
Total Phosphorus (mg/l)	0 m	"	"
Ortho-Phosphorus (mg/l)	0 m	"	"
Total Suspended Solids (mg/l)	0 m	"	APHA (1989)
Total Dissolved Solids (mg/l)	0 m	"	"
Biological			
BOD_5 (mg/l)	0 m	"	"
Fecal Coliforms (MPN/100ml)	0 m	"	"

B. Temporal Variations in Water Quality

Water temperatures in Las Vegas Wash increased from a minimum of about 13 °C during January to a maximum of 30°C during July and August (Figure 3). Dissolved oxygen concentrations varied inversely with seasonal changes in temperature (Figure 3). Dissolved oxygen concentrations ranged between 8 - 11 mg/l during winter and spring but decreased to about 6 - 7 mg/l at LVW-A and 7 - 8 mg/l at LVW-B during summer (Figure 3). Dissolved oxygen concentrations increased back to 8 - 10 mg/l at both stations during the fall (Figure 3). Dissolved oxygen concentrations were consistently 1 - 2 mg/l higher at LVW-B. The pH at both stations ranged between 7.0 and 7.8 throughout the year (Figure 3). The pH was about 0.1 - 0.2 units higher at LVW-B.

Conductance ranged from a minimum of about 1600 - 1900 µmho/cm during a flood on August 9 to a maximum of about 3000 µmho/cm during early spring (Figure 4). Conductance decreased to about 2400 - 2500 µmho/cm during summer and remained near those levels for the rest of the year (Figure 4). Seasonal variations in total dissolved solids (TDS) were similar to those observed for conductance (Figure 4). TDS ranged from a minimum about 1100 mg/l during a moderate flood on August 9 to a maximum of about 2200 mg/l during early spring. There were minimal variations in either TDS or conductance between stations LVW-A and LVW-B.

Total suspended solids (TSS) ranged from a minimum of about 5 - 15 mg/l during April - July (Figure 5). TSS reached nearly 1000 mg/l during the flood on August 9 and during an event of unknown origin on July 19 (Figure 5). TSS averaged about 40 - 60 mg/l during the rest of the year. Turbidity followed trends similar to those observed for TSS (Figure 5).

Total phosphorus concentrations in Las Vegas Wash ranged from a minimum of 0.1 - 0.2 mg/l during April - July (Figure 6). Total phosphorus increased to a maximum of 1.5 -1.6 mg/l during the August 9 flood and the July 19 event (Figure 6). Total phosphorus concentrations showed some seasonality in that concentrations were highest during the winter, early spring and fall months. The same pattern was evident in ortho-phosphorus concentrations (Figure 6). Ortho-phosphorus reached maximum levels of 0.5 - 0.6 mg/l during winter. Ortho-phosphorus dropped to about 0.1 - 0.2 mg/l during summer, except during the July 19 event when concentrations increased to about 0.35 mg/l.

Total Kjeldahl nitrogen ranged from a minimum of about 7.5 mg/l during the August 9 flood to a maximum of about 14 - 16 mg/l during winter (Figure 7). Ammonia-N concentrations ranged from a minimum of about 4.5 mg/l during the August 9 flood to a maximum of about 14 mg/l during winter (Figure 7). Ammonia-N and total Kjeldahl nitrogen concentrations showed seasonal patterns similar to those for phosphorus. Nitrite+nitrate-N concentrations at both stations ranged between 2 - 3 mg/l early in 1994, then increased to about 5 mg/l during the rest of the year (Figure 7). Nitrite+nitrate-N reached a maximum of nearly 9 mg/l on December 13 at both stations.

C. Spatial Variations in Water Quality

Annual averages for physical measurements and chemical and biological analyses at stations LVW-A and LVW-B were virtually identical, except for dissolved oxygen (Table 4). Dissolved oxygen concentrations averaged 1.1 mg/l higher at station LVW-B.

Table 2. Precision estimates for physical measurements and chemical and biological constituents based on analyses of duplicate grab samples collected in Las Vegas Wash during 1994.

Statistics	Temperature (°C)	Oxygen (mg/l)	Conductance (µM/cm)	pH (Std. Units)	TDS (mg/l)	TSS (mg/l)	Turbidity (NTU)	Fecal Coliform (MPN/100ml)
Average % Difference	1.3	1.4	1.4	0.5	2.3	24.0	12.4	77.1
Standard Deviation	2.8	1.2	3.1	0.4	4.0	21.4	18.8	49.3
Number of Observations	24	24	24	24	12	12	12	12

Table 2. continued.

Statistics	Ammonia-N (mg/l)	Nitrite+Nitrate-N (mg/l)	TKN (mg/l)	Ortho-P (mg/l)	Total-P (mg/l)	BOD_5 (mg/l)
Average % Difference	6.5	2.6	4.1	4.4	5.2	12.5
Standard Deviation	4.4	1.5	3.1	3.5	3.8	18.5
Number of Observations	12	12	12	12	12	12

Table 3. Accuracy estimates for chemical and biological constituents based on half-dilutions of grab samples collected in Las Vegas Wash during 1994.

Statistics	Ammonia-N (mg/l)	Nitrite+Nitrate-N (mg/l)	TKN (mg/l)	Ortho-P (mg/l)	Total-P (mg/l)
Average % Dilution	52.4	49.7	54.4	51.3	52.2
Standard Deviation	8.0	1.0	3.4	2.6	4.3
Number of Observations	12	12	12	12	12

Table 3. continued.

Statistics	TDS (mg/l)	TSS (mg/l)	BOD_5 (mg/l)	Fecal Coliform (MPN/100ml)	Turbidity (NTU)
Average % Dilution	50.3	52.5	49.3	46.1	58.9
Standard Deviation	1.8	11.7	16.9	27.4	11.4
Number of Observations	12	12	12	12	12

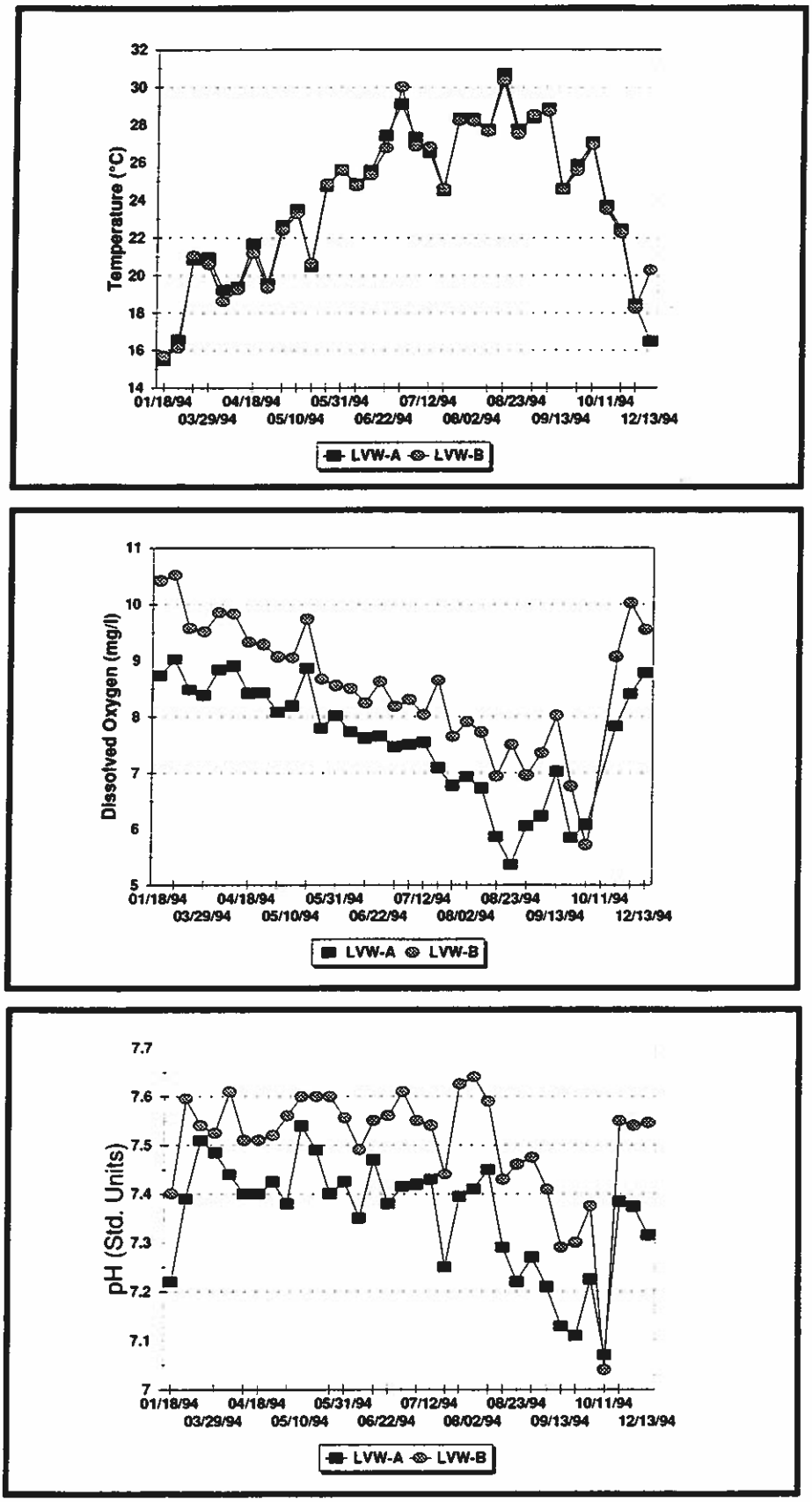

Figure 3. Seasonal variations in temperature (°C), dissolved oxygen (mg/l) and pH (Std. Units) in Las Vegas Wash upstream (LVW-A) and downstream (LVW-B) of Lake Las Vegas during 1994.

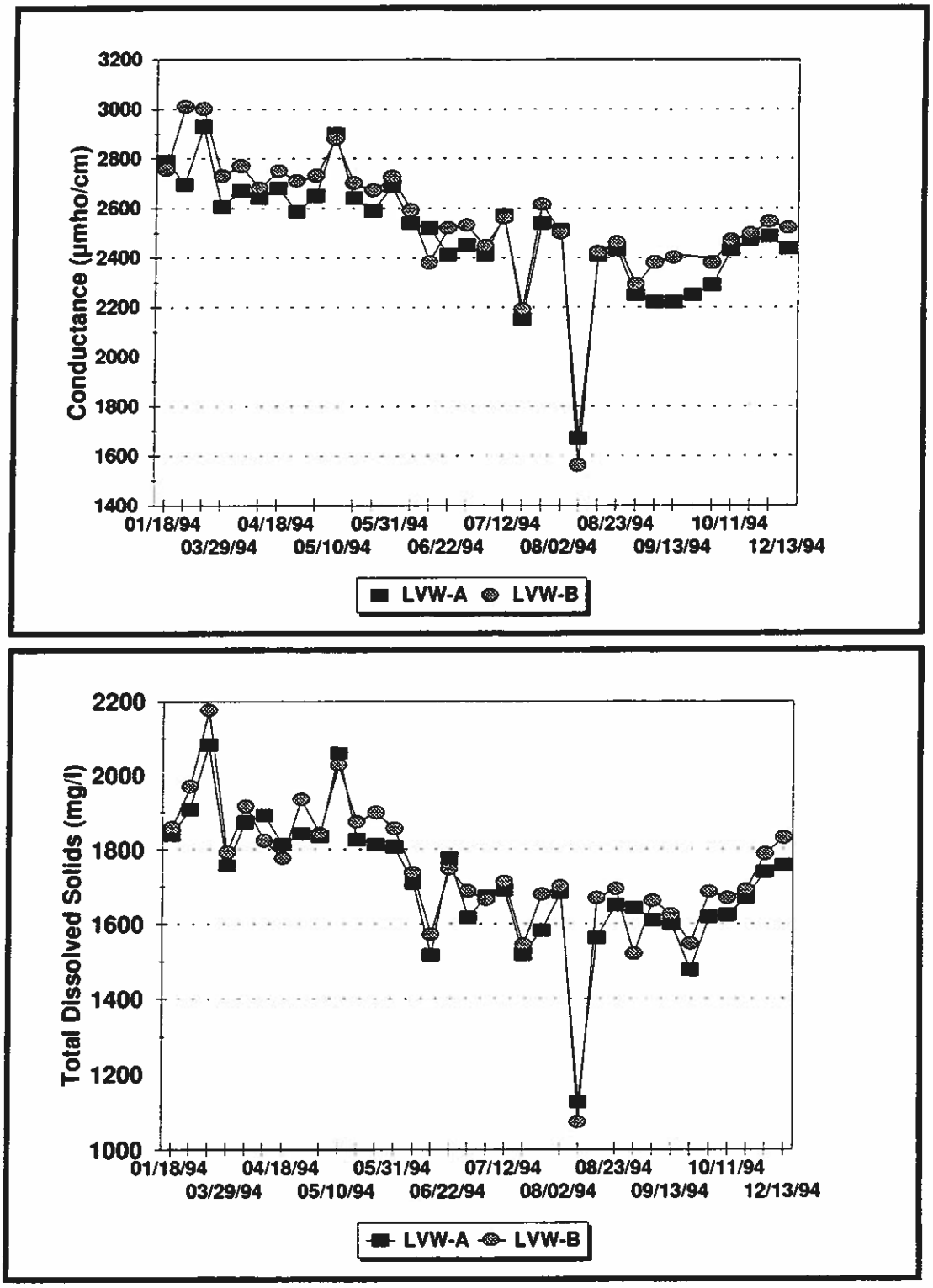

Figure 4. Seasonal variations in conductance (µmho/cm) and total dissolved solids (mg/l) in Las Vegas Wash upstream (LVW-A) and downstream (LVW-B) of Lake Las Vegas during 1994.

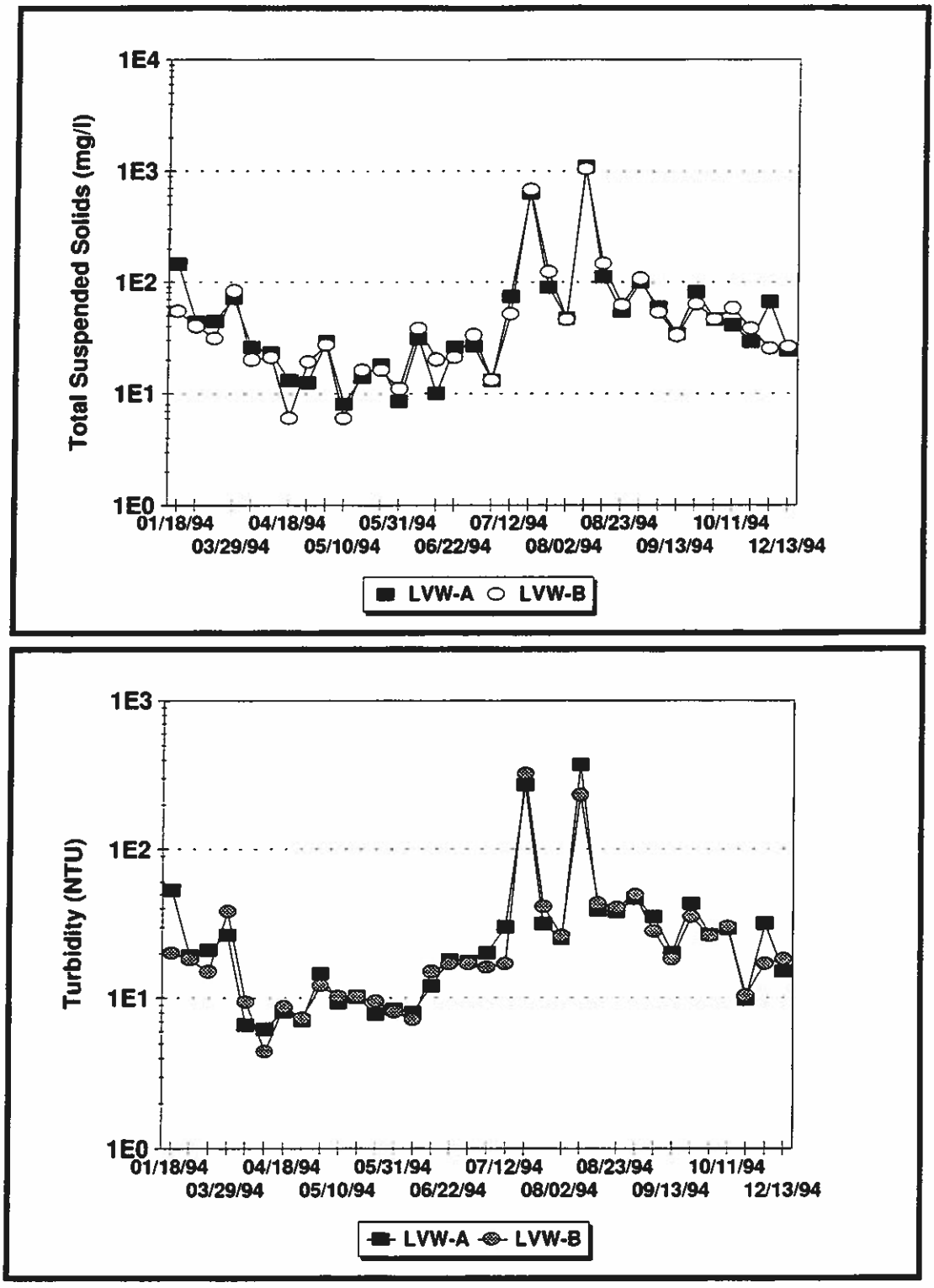

Figure 5. Seasonal variations in total suspended solids (mg/l) and turbidity (NTU) in Las Vegas Wash upstream (LVW-A) and downstream (LVW-B) of Lake Las Vegas during 1994.

D. Water Quality Standards

The water quality standards for Las Vegas Wash near LLV are presented in Table 5. The water quality standards were established to protect and enhance the following beneficial uses (from NAC 445.1356):

1) Irrigation;
2) Watering of livestock;
3) Recreation not involving contact with water;
4) Maintenance of a freshwater marsh;
5) Propagation of wildlife, and
6) Propagation of aquatic life, excluding fish. This does not preclude the establishment of a fishery.

Water quality measurements made during 1994 show that water quality standards are currently being attained in Las Vegas Wash (Tables 4,5). Total inorganic nitrogen, nitrate, and nitrite concentrations, and pH (Table 4) were well within the range of the standards (Table 5).

Average fecal coliform counts at LVW-A exceeded the 200 MPN/100ml standard established for point source discharges to Las Vegas Wash during July, August and September (Table 4, Figure 8). Fecal coliform counts were within acceptable levels the rest of the year. There are no state standards for biochemical oxygen demand (BOD_5) in this reach of Las Vegas Wash. Occasionally, BOD_5 exceeded 30 mg/l at both stations (Figure 8).

Construction and operation of Lake Las Vegas did not have any adverse effects on water quality in Las Vegas Wash during 1994. Water quality downstream of the project was similar to that upstream. A flood on August 9, and an event of unknown origin on July 19, did however have significant effects on water quality in the wash. Phosphorus concentrations, total suspended solids, turbidity, and fecal coliforms increased considerably during these two sampling dates. Ammonia-N, total Kjeldahl nitrogen, TDS and conductance decreased during the August 9 flood.

Aeration in the Lake Las Vegas bypass pipeline routinely increased oxygen concentrations in Las Vegas Wash by 1 - 2 mg/l during 1994. This trend has been observed ever since wash flows were diverted into the bypass pipleline in February 1990. This aeration has a postive influence on water quality in the wash since wastewaters enter Lake Mead at a higher oxygen content.

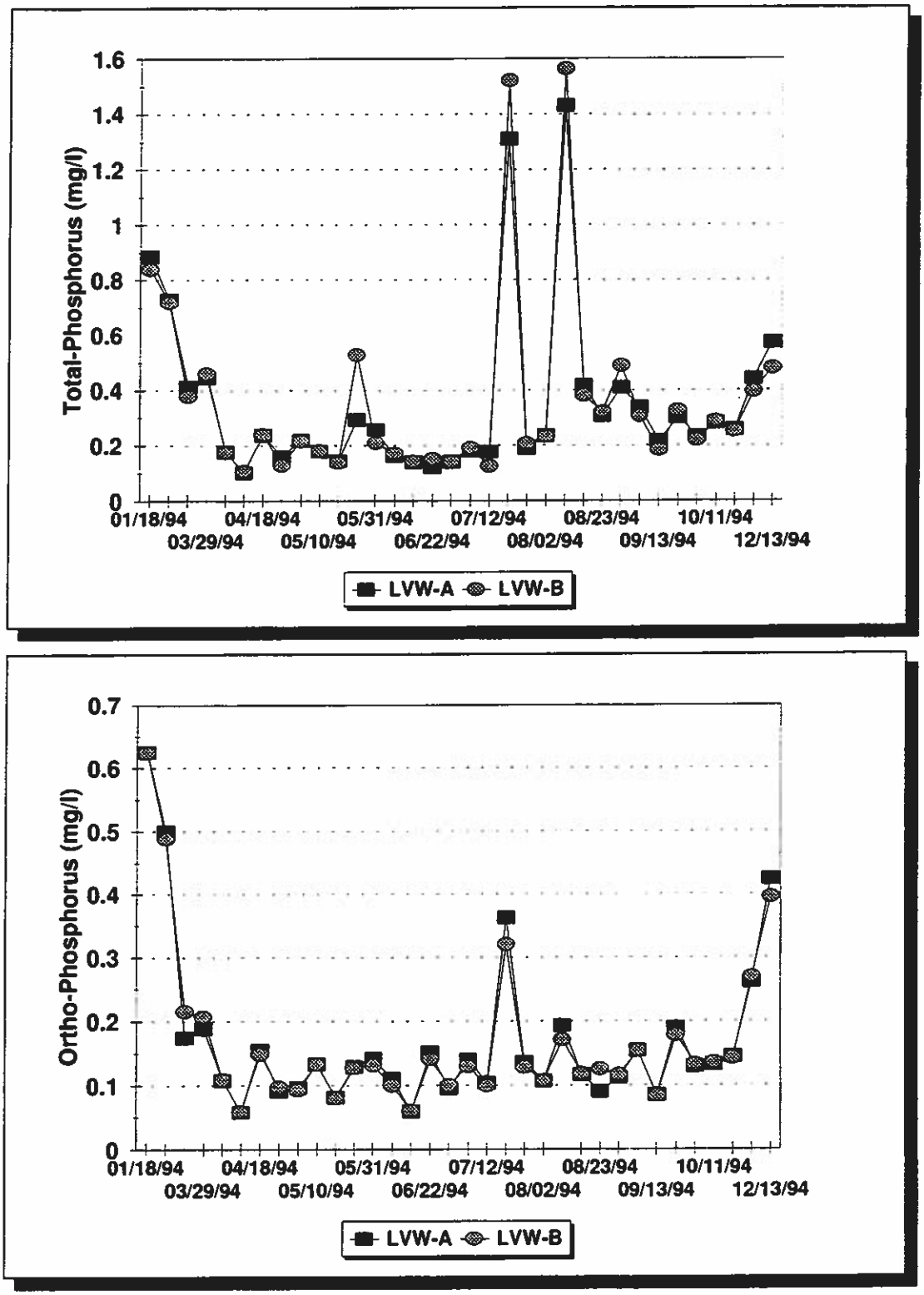

Figure 6. Seasonal variations in total phosphorus and ortho-phosphorus concentrations in Las Vegas Wash upstream (LVW-A) and downstream (LVW-B) of Lake Las Vegas during 1994.

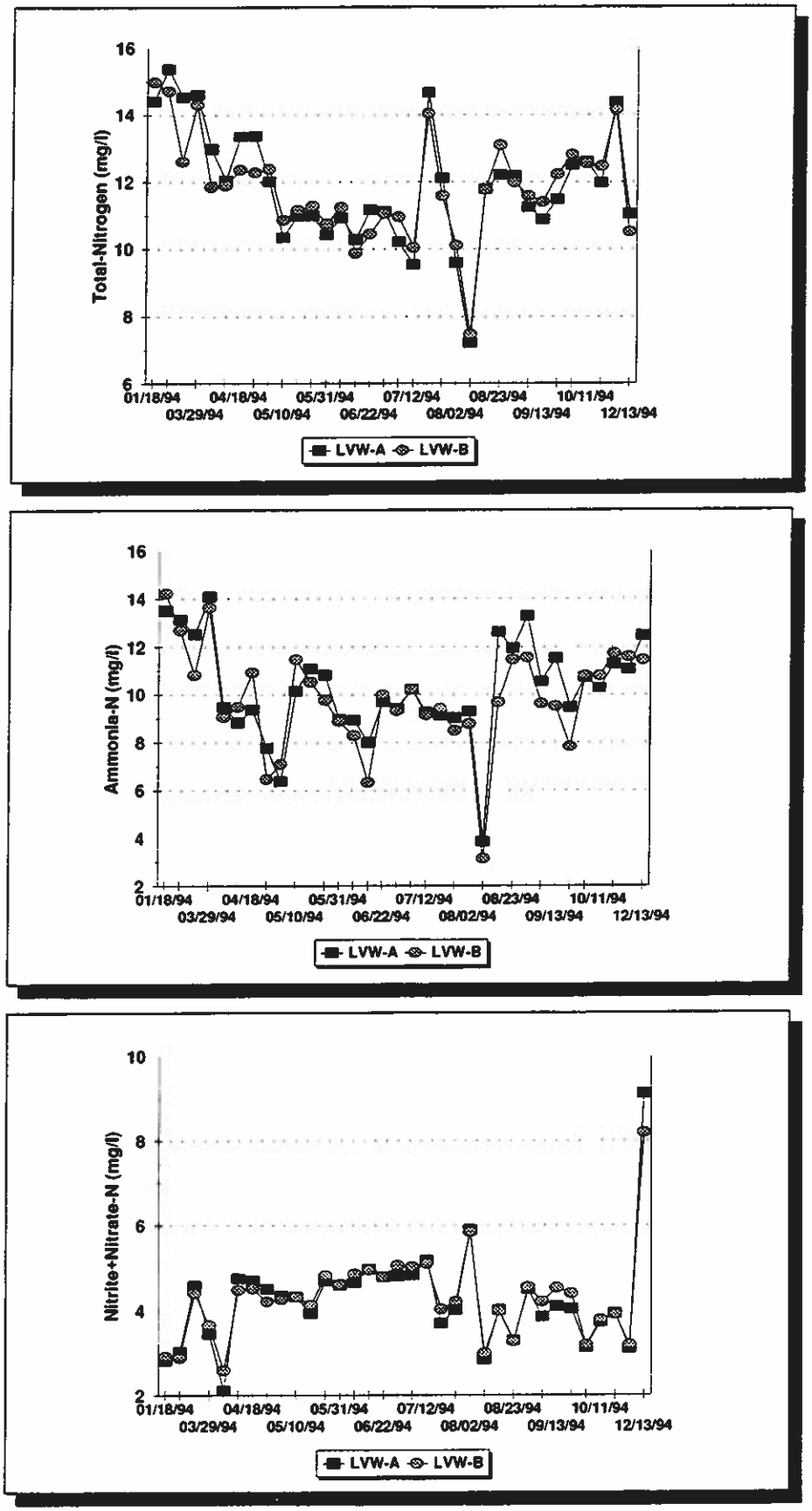

Figure 7. Seasonal variations in total Kjeldahl nitrogen, ammonia-N, and nitrite+nitrate-N concentrations in Las Vegas Wash upstream (LVW-A) and downstream (LVW-B) of Lake Las Vegas during 1994.

Table 4. Monthly and annual averages for physical, chemical and biological measurements on surface grab samples collected in Las Vegas Wash upstream (LVW-A) and downstream (LVW-B) of Lake Las Vegas during 1994.

STATION	DATE	Temp. (°C)	Dissolved Oxygen (mg/l)	Cond. (µM/cm)	pH (Std.)	Ammonia-N (mg/l)	Nitrite+ Nitrate-N (mg/l)	TKN (mg/l)	Ortho-P (mg/l)	Total-P (mg/l)	TDS (mg/l)	TSS (mg/l)	BOD_5 (mg/l)	Fecal Coliform (MPN/100ml)	Turbidity (NTU)
LVW-A	January	15.5	8.7	2790	7.2	13.5	2.8	14.4	0.63	0.89	1840	145	30	3	53
LVW-A	February	16.6	9.0	2695	7.4	13.1	3.0	15.4	0.49	0.73	1909	43	20	5	19
LVW-A	March	20.9	8.4	2768	7.5	13.3	4.0	14.6	0.18	0.43	1920	58	28	16	24
LVW-A	April	20.0	8.7	2644	7.4	8.9	4.0	12.9	0.10	0.17	1855	19	11	23	7
LVW-A	May	23.4	8.2	2694	7.5	9.5	4.4	11.0	0.12	0.22	1868	16	8	35	10
LVW-A	June	26.7	7.6	2480	7.4	9.0	4.8	10.9	0.10	0.14	1654	23	9	19	14
LVW-A	July	26.7	7.2	2418	7.4	9.4	4.4	11.6	0.19	0.46	1617	202	19	40094	88
LVW-A	August	28.6	6.2	2254	7.3	10.2	4.1	10.6	0.12	0.56	1533	281	22	4656	104
LVW-A	September	26.6	6.3	2245	7.2	10.6	3.8	11.5	0.14	0.27	1576	55	20	12601	31
LVW-A	October	23.1	7.8	2450	7.2	10.8	3.8	12.3	0.14	0.27	1647	35	23	21	19
LVW-A	November	18.5	8.4	2485	7.4	11.1	3.1	14.4	0.26	0.44	1740	66	26	19	32
LVW-A	December	16.5	8.8	2435	7.3	12.5	9.1	11.1	0.42	0.57	1757	25	32	25	15
Annual Average		21.9	7.9	2530	7.4	11.0	4.3	12.5	0.24	0.43	1743	81	21	4793	35
Standard Deviation		4.4	0.9	178	0.1	1.7	1.6	1.6	0.17	0.22	130	81	8.0	11226	30
LVW-B	January	15.7	10.4	2755	7.4	14.2	2.9	15.0	0.62	0.84	1857	54	27	2	20
LVW-B	February	16.1	10.5	3010	7.6	12.7	2.9	14.7	0.49	0.72	1970	40	16	8	18
LVW-B	March	20.8	9.5	2865	7.5	12.2	4.0	13.5	0.21	0.42	1984	57	29	22	27
LVW-B	April	19.6	9.6	2728	7.5	9.0	3.9	12.1	0.10	0.16	1863	17	12	15	7
LVW-B	May	23.4	9.0	2741	7.5	9.5	4.4	11.3	0.11	0.25	1899	15	8	41	10
LVW-B	June	26.7	8.4	2505	7.6	8.5	4.9	10.7	0.10	0.15	1686	28	10	37	14
LVW-B	July	26.6	8.2	2453	7.5	9.3	4.6	11.7	0.17	0.51	1650	215	19	40098	99
LVW-B	August	28.4	7.4	2246	7.5	8.9	4.1	10.9	0.13	0.60	1530	282	24	4814	78
LVW-B	September	26.4	7.0	2238	7.3	9.4	4.1	12.0	0.14	0.26	1630	49	23	3325	27
LVW-B	October	22.9	9.1	2483	7.3	11.3	3.8	12.5	0.14	0.27	1680	48	23	55	20
LVW-B	November	18.3	10.0	2545	7.5	11.6	3.2	14.2	0.27	0.39	1787	25	19	13	17
LVW-B	December	22.5	8.7	2422	7.4	11.5	8.2	10.5	0.40	0.48	1831	26	30	30	18
Annual Average		22.3	9.0	2599	7.5	10.7	4.3	12.4	0.24	0.42	1781	68	20	4038	30
Standard Deviation		4.1	1.1	211	0.1	1.7	1.3	1.5	0.17	0.21	138	83	7.0	10979	27

Table 5. Water quality standards for Las Vegas Wash near Lake Las Vegas (Source: NAC 445.1367).

PARAMETER	REQUIREMENTS TO MAINTAIN EXISTING HIGHER QUALITY	WATER QUALITY STANDARDS FOR BENEFICIAL USES	BENEFICIAL USES
Temperature (C) Single Value [a]	0	-	-
pH- Standard Units			Wildlife propagation.[d] Agricultural use.[d]
Single Value of 90% of Samples	Within Range 7.2-8.7	Within Range 7.0-9.0	
Dissolved Oxygen-mg/l		b	Stock watering.[d] Non-contact sports, & esthetics.[d] Wildlife propagation.[d]
Nitrogen Single Value in 90% of Samples	Total Inorganic Nitrogen 17	Nitrate Nitrite 100 100	Stock watering.[d] as N-mg/l Wildlife propagation.[d]
Total Filterable Residue at (180 C) (mg/l) Single Value in 90% of Samples[f]	2600	3000	Stock watering.[d] Irrigation. Freshwater marsh maintenance
Fecal Coliform MF/100ml	-	c	Non-contact sports & esthetics.[d] Wildlife propagation.[d] Agricultural use.

[a]Maximum allowable increase in temperature above receiving water temperature at the boundary of an approved mixing zone.

[b]It is known that aerobic conditions are desirable for the beneficial uses of stock watering, noncontact sports and esthetics and wildlife propagation. Existing conditions prevent the attainment of aerobic conditions at this time. Therefore aerobic conditions are established as a goal rather than a standard and is not intended to preclude development of a limited fishery in selected areas. Aerobic conditions is intended to mean absence of objectionable odors that may be caused by wastewater discharges in excess of existing odors.

[c]Any discharge from a point source into Las Vegas Wash must not exceed a log mean of 200 per 100 ml, based on a minimum of not less than five samples taken over a 30-day period nor may more than 10 percent of the total samples taken during any 30-day period exceed 400 per 100 ml.

[d]The most significant beneficial uses

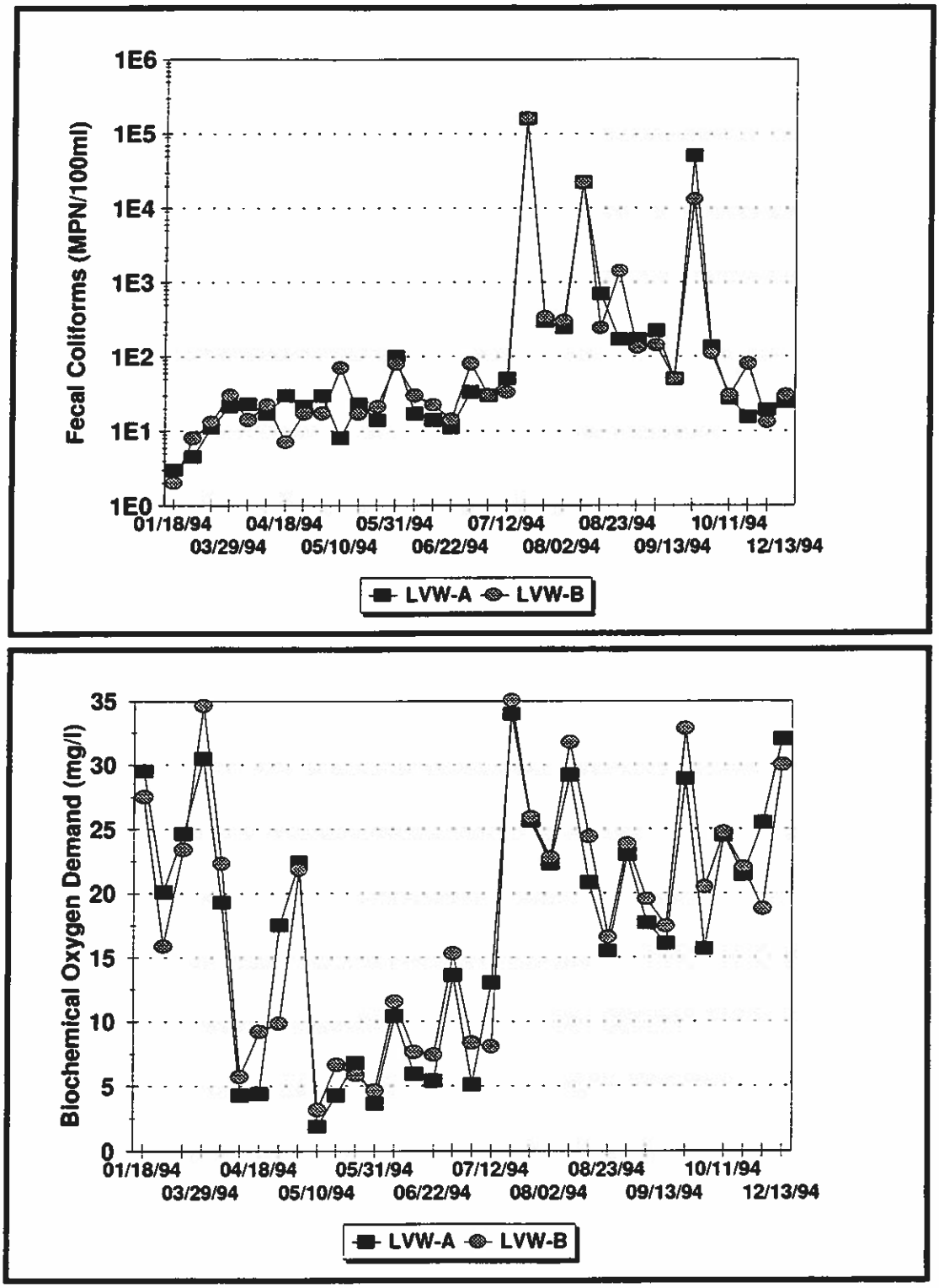

Figure 8. Seasonal variations in fecal coliform counts and biochemical oxygen demand (BOD_5) upstream (LVW-A) and downstream (LVW-B) of Lake Las Vegas during 1994.

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VII. APPENDICES

Appendix 1. Physical monitoring data for Las Vegas Wash upstream (LVW-A) and downstream (LVW-B) of Lake Las Vegas during 1994.

Station	Date	Time	Sample Type	Temperature (C)	Dissolved Oxygen (mg/l)	Specific Conductance (umho/cm)	pH (Std. Units)
LVW-A1	01/18/94	1245	R	14.34	8.82	2810	7.18
LVW-A2	01/18/94	1255	FD	16.57	8.64	2770	7.26
LVW-B1	01/18/94	1225	R	15.44	10.58	2650	7.38
LVW-B2	01/18/94	1230	FD	15.87	10.25	2860	7.42
LVW-A1	02/22/94	1230	R	16.50	9.10	2500	7.42
LVW-A2	02/22/94	1230	FD	16.60	8.94	2890	7.36
LVW-B1	02/22/94	1200	R	16.12	10.53	3010	7.60
LVW-B2	02/22/94	1200	FD	16.11	10.50	3010	7.59
LVW-A	03/15/94	1310	R	20.85	8.48	2930	7.51
LVW-B	03/15/94	1250	R	21.01	9.57	3000	7.54
LVW-A1	03/29/94	1330	R	20.88	8.50	2610	7.50
LVW-A2	03/29/94	1330	FD	21.02	8.25	2600	7.47
LVW-B1	03/29/94	1255	R	20.64	9.49	2740	7.54
LVW-B2	03/29/94	1255	FD	20.54	9.52	2720	7.51
LVW-A	04/04/94	1145	R	19.21	8.83	2670	7.44
LVW-B	04/04/94	1131	R	18.61	9.85	2770	7.61
LVW-A	04/11/94	1145	R	19.40	8.91	2640	7.40
LVW-B	04/11/94	1130	R	19.22	9.82	2680	7.51
LVW-A	04/18/94	1145	R	21.67	8.42	2680	7.40
LVW-B	04/18/94	1125	R	21.18	9.32	2750	7.51
LVW-A1	04/26/94	1250	R	19.58	8.47	2590	7.41
LVW-A2	04/26/94	1250	FD	19.54	8.38	2580	7.44
LVW-B1	04/26/94	1205	R	19.39	9.45	2710	7.54
LVW-B2	04/26/94	1205	FD	19.23	9.11	2710	7.50
LVW-A	05/03/94	1215	R	22.64	8.08	2650	7.38
LVW-B	05/03/94	1200	R	22.41	9.06	2730	7.56
LVW-A	05/10/94	1310	R	23.51	8.19	2900	7.54
LVW-B	05/10/94	1245	R	23.27	9.04	2880	7.60
LVW-A	05/17/94	1200	R	20.45	8.86	2640	7.49
LVW-B	05/17/94	1148	R	20.62	9.73	2700	7.60
LVW-A	05/24/94	1210	R	24.71	7.80	2590	7.40
LVW-B	05/24/94	1150	R	24.86	8.67	2670	7.60
LVW-A1	05/31/94	1310	R	25.61	8.03	2690	7.42
LVW-A2	05/31/94	1310	FD	25.59	8.01	2690	7.43
LVW-B1	05/31/94	1250	R	25.67	8.62	2720	7.55
LVW-B2	05/31/94	1250	FD	25.50	8.48	2730	7.56
LVW-A	06/08/94	1200	R	24.85	7.73	2540	7.35
LVW-B	06/08/94	1145	R	24.76	8.49	2590	7.49
LVW-A	06/17/94	1206	R	25.56	7.62	2520	7.47
LVW-B	06/17/94	1145	R	25.33	8.24	2380	7.55
LVW-A	06/22/94	1200	R	27.40	7.65	2410	7.38
LVW-B	06/22/94	1130	R	26.74	8.62	2520	7.56
LVW-A1	06/28/94	1345	R	29.12	7.42	2440	7.41
LVW-A2	06/28/94	1345	FD	29.11	7.50	2460	7.42
LVW-B1	06/28/94	1325	R	30.01	8.20	2510	7.61
LVW-B2	06/28/94	1325	FD	29.99	8.16	2550	7.61
LVW-A	07/05/94	1215	R	27.33	7.50	2410	7.42

 R=Routine Sample F=Flood Sample FD=Field Duplicate Sample

Appendix 1. Physical monitoring data for Las Vegas Wash upstream (LVW-A) and downstream (LVW-B) of Lake Las Vegas during 1994.

Station	Date	Time	Sample Type	Temperature (C)	Dissolved Oxygen (mg/l)	Specific Conductance (umho/cm)	pH (Std. Units)
LVW-B	07/05/94	1145	R	26.86	8.30	2445	7.55
LVW-A	07/12/94	1125	R	26.54	7.54	2570	7.43
LVW-B	07/12/94	1105	R	26.82	8.03	2560	7.54
LVW-A	07/19/94	0610	F	24.52	7.09	2150	7.25
LVW-B	07/19/94	0550	F	24.62	8.64	2190	7.44
LVW-A1	07/26/94	1215	R	28.47	6.70	2530	7.40
LVW-A2	07/26/94	1215	FD	28.23	6.85	2550	7.39
LVW-B1	07/26/94	1150	R	28.41	7.60	2620	7.68
LVW-B2	07/26/94	1150	FD	28.01	7.69	2610	7.57
LVW-A	08/02/94	1210	R	28.31	6.93	2510	7.41
LVW-B	08/02/94	1155	R	28.16	7.91	2500	7.64
LVW-A	08/09/94	1235	R	27.72	6.73	1670	7.45
LVW-B	08/09/94	1220	R	27.64	7.72	1560	7.59
LVW-A	08/16/94	1320	R	30.72	5.86	2410	7.29
LVW-B	08/16/94	1240	R	30.32	6.94	2420	7.43
LVW-A	08/23/94	1210	R	27.75	5.36	2430	7.22
LVW-B	08/23/94	1150	R	27.50	7.50	2460	7.46
LVW-A1	08/30/94	1550	R	28.43	6.05	2250	7.27
LVW-A2	08/30/94	1550	FD	28.29	6.05	2250	7.27
LVW-B1	08/30/94	1530	R	28.61	6.97	2290	7.48
LVW-B2	08/30/94	1530	FD	28.39	6.94	2290	7.47
LVW-A	09/06/94	1252	R	28.85	6.23	2220	7.21
LVW-B	09/06/94	1238	R	28.68	7.35	2380	7.41
LVW-A	09/13/94	1246	R	24.60	7.02	2220	7.13
LVW-B	09/13/94	1229	R	24.56	8.02	2400	7.29
LVW-A	09/20/94	1305	R	25.88	5.84	2250	7.11
LVW-B	09/20/94	1244	R	25.56	6.76		7.30
LVW-A1	09/27/94	1254	R	27.17	6.04	2300	7.21
LVW-A2	09/27/94	1254	FD	26.98	6.10	2280	7.24
LVW-B1	09/27/94	1224	R	26.72	5.74	2380	7.42
LVW-B2	09/27/94	1224	FD	27.12	5.69	2380	7.33
LVW-A	10/11/94	1230	R	23.71		2430	7.07
LVW-B	10/11/94	1210	R	23.49		2470	7.04
LVW-A1	10/26/94	1300	R	22.43	7.76	2470	7.40
LVW-A2	10/26/94	1300	FD	22.51	7.89	2470	7.37
LVW-B1	10/26/94	1230	R	22.27	9.26	2480	7.55
LVW-B2	10/26/94	1230	FD	22.29	8.86	2510	7.55
LVW-A1	11/15/94	1310	R	18.36	8.45	2490	7.39
LVW-A2	11/15/94	1310	FD	18.54	8.36	2480	7.36
LVW-B1	11/15/94	1245	R	18.12	10.10	2550	7.54
LVW-B2	11/15/94	1245	FD	18.39	9.94	2540	7.54
LVW-A1	12/13/94	1320	R	16.38	8.82	2450	7.34
LVW-A2	12/13/94	1320	FD	16.59	8.74	2420	7.29
LVW-B1	12/13/94	1300	R	16.35	10.12	2520	7.58
LVW-B2	12/13/94	1300	FD	16.28	10.12	2550	7.49

 R=Routine Sample F=Flood Sample FD=Field Duplicate Sample

Appendix 2. Chemical and biological monitoring data for Las Vegas Wash upstream (LVW-A) and downstream (LVW-B) of Lake Las Vegas during 1994.

Station	Date	Time	Chain of Custody	Sample Type	BOD-5 (mg/l)	Fecal Coliforms (MPN/100ml)	Total Dissolved Solids (mg/l)	Total Suspended Solids (mg/l)	Turbidity (NTU)	Phosphorus		Nitrogen		
										Ortho-P (mg/l)	Total-P (mg/l)	NO2+NO3-N (mg/l)	NH3-N (mg/l)	TKN (mg/l)
LVW-A1	01/18/94	1245	2008	R	31.7	4	1836	143	53	0.623	0.868	2.9	14.1	14.6
LVW-A2	01/18/94	1255	2009	FD	27.3	2	1843	146	53	0.627	0.903	2.8	12.9	14.2
LVW-B1	01/18/94	1225	2010	R	27.5	2	1857	54	20	0.624	0.839	2.9	14.2	15.0
LVW-B2	01/18/94	1230	2011	H	15.7	2	934	21	11	0.336	0.394	1.5	7.6	8.0
LVW-A1	02/22/94	1230	2066	R	20.0	7	1931	39	20	0.513	0.738	3.0	13.1	15.2
LVW-A2	02/22/94	1230	2067	FD	20.2	2	1887	47	18	0.485	0.719	3.1	13.2	15.6
LVW-B1	02/22/94	1200	2068	R	15.8	8	1970	40	18	0.488	0.719	2.9	12.7	14.7
LVW-B2	02/22/94	1200	2069	H	9.5	2	966	23	11	0.248	0.363	1.5	6.8	7.3
LVW-A	03/15/94	1310	2106	R	24.6	11	2083	44	21	0.174	0.412	4.6	12.5	14.5
LVW-B	03/15/94	1250	2106	R	23.4	13	2175	31	15	0.214	0.377	4.4	10.8	12.6
LVW-A1	03/29/94	1330	2130	R	29.3	13	1779	73	26	0.186	0.434	3.4	13.9	14.5
LVW-A2	03/29/94	1330	2131	FD	31.6	30	1735	69	27	0.190	0.455	3.5	14.3	14.7
LVW-B1	03/29/94	1255	2132	R	34.6	30	1792	83	38	0.206	0.458	3.7	13.6	14.3
LVW-B2	03/29/94	1255	2133	H	10.4	17	842	47	20	0.111	0.221	1.8	10.6	7.5
LVW-A	04/04/94	1145	2152	R	19.3	23	1874	26	7	0.108	0.175	2.1	9.5	13.0
LVW-B	04/04/94	1131	2153	R	22.3	14	1916	20	9	0.108	0.172	2.6	9.1	11.8
LVW-A	04/11/94	1145	2169-5	R	4.3	17	1891	23	6	0.058	0.099	4.8	8.8	12.0
LVW-B	04/11/94	1130	2169-6	R	5.7	22	1824	21	4	0.058	0.104	4.5	9.5	11.9
LVW-A	04/18/94	1145	2177-6	R	4.4	30	1812	13	8	0.155	0.236	4.7	9.4	13.4
LVW-B	04/18/94	1125	2177-5	R	9.2	7	1776	6	9	0.148	0.236	4.5	10.9	12.4
LVW-A1	04/26/94	1250	2195-1	R	17.6	30	1857	9	7	0.096	0.166	4.5	7.4	13.4
LVW-A2	04/26/94	1250	2195-2	FD	17.4	12	1828	16	7	0.085	0.148	4.5	8.1	13.3
LVW-B1	04/26/94	1205	2195-3	R	9.8	17	1934	19	7	0.096	0.128	4.2	6.5	12.3
LVW-B2	04/26/94	1205	2195-4	H	5.8	7	967	10	4	0.049	0.072	2.2	3.3	7.0
LVW-A	05/03/94	1215	2210-1	R	22.4	30	1835	29	15	0.096	0.217	4.4	6.4	12.0
LVW-B	05/03/94	1200	2210-2	R	21.8	17	1843	27	12	0.092	0.215	4.3	7.1	12.4
LVW-A	05/10/94	1310	2218-1	R	1.9	8	2059	8	9	0.133	0.178	4.3	10.2	10.4
LVW-B	05/10/94	1245	2218-2	R	3.1	70	2027	6	10	0.133	0.180	4.3	11.5	10.9
LVW-A	05/17/94	1200	2229-1	R	4.3	23	1826	14	10	0.082	0.143	3.9	11.1	11.0
LVW-B	05/17/94	1148	2229-2	R	6.6	17	1873	16	10	0.080	0.136	4.1	10.5	11.2
LVW-A	05/24/94	1210	2237-1	R	6.8	14	1813	18	8	0.129	0.292	4.7	10.8	11.0
LVW-B	05/24/94	1150	2237-2	R	5.8	21	1899	16	10	0.126	0.527	4.8	9.8	11.3
LVW-A1	05/31/94	1310	2249-1	R	3.5	170	1814	11	9.0	0.142	0.270	4.6	9.0	10.4
LVW-A2	05/31/94	1310	2249-2	FD	3.8	30	1799	6	7.8	0.140	0.244	4.6	9.0	10.5
LVW-B1	05/31/94	1250	2249-3	R	4.6	80	1855	11	8.1	0.132	0.209	4.6	8.9	10.8
LVW-B2	05/31/94	1250	2249-4	H	3.0	17	980	4	3.5	0.064	0.104	2.3	4.7	5.5
LVW-A	06/08/94	1200	2269-1	R	10.4	17	1709	31	8	0.110	0.160	4.7	8.9	10.9
LVW-B	06/08/94	1145	2269-2	R	11.5	30	1737	38	7	0.100	0.170	4.9	8.3	11.2
LVW-A	06/17/94	1206	2271-1	R	5.9	14	1516	10	12	0.060	0.140	5.0	8.0	10.3
LVW-B	06/17/94	1145	2271-2	R	7.6	22	1571	20	15	0.060	0.140	5.0	6.3	9.9
LVW-A	06/22/94	1200	2304-1	R	5.4	11	1776	26	18	0.150	0.120	4.8	9.7	11.2
LVW-B	06/22/94	1130	2304-2	R	7.4	14	1747	21	17	0.140	0.150	4.8	10.0	10.5
LVW-A1	06/28/94	1345	2315-1	R	18.2	17	1633	27	17	0.100	0.140	5.0	8.8	10.9
LVW-A2	06/28/94	1345	2315-2	FD	8.9	50	1599	26	18	0.090	0.140	4.7	10.0	11.3
LVW-B1	06/28/94	1325	2315-3	R	15.3	80	1687	33	17	0.100	0.140	5.1	9.3	11.1
LVW-B2	06/28/94	1325	2315-4	H	3.5	7	833	16	15	0.050	0.090	2.5	4.3	6.0
LVW-A	07/05/94	1215	2324-1	R	5.1	30	1674	13	20	0.140	0.180	4.8	10.2	10.2
LVW-B	07/05/94	1145	2324-2	R	8.3	30	1664	13	16	0.130	0.190	5.0	10.2	11.0
LVW-A	07/12/94	1125	2333-1	R	13.0	50	1690	74	30	0.104	0.175	5.2	9.2	9.5
LVW-B	07/12/94	1105	2333-2	R	8.0	33	1712	51	17	0.099	0.123	5.1	9.1	10.1
LVW-A	07/19/94	0610	2340-1	F	34.0	160000	1519	633	270	0.362	1.310	3.7	9.1	14.7

R=Routine Sample F=Flood Sample FD=Field Duplicate Sample H=Half Dilution Sample

Appendix 2. Chemical and biological monitoring data for Las Vegas Wash upstream (LVW-A) and downstream (LVW-B) of Lake Las Vegas during 1994.

Station	Date	Time	Chain of Custody	Sample Type	BOD-5 (mg/l)	Fecal Coliforms (MPN/100ml)	Total Dissolved Solids (mg/l)	Total Suspended Solids (mg/l)	Turbidity (NTU)	Phosphorus		Nitrogen		
										Ortho-P (mg/l)	Total-P (mg/l)	NO2+NO3-N (mg/l)	NH3-N (mg/l)	TKN (mg/l)
LVW-B	07/19/94	0550	2340-2	F	35.0	160000	1544	673	320	0.320	1.520	4.0	9.4	14.0
LVW-A1	07/26/94	1215	2345-1	R	26.3	350	1579	82	30	0.139	0.175	4.1	9.0	11.6
LVW-A2	07/26/94	1215	2345-2	FD	25.0	240	1587	97	33	0.132	0.198	4.0	9.0	12.7
LVW-B1	07/26/94	1150	2345-3	R	25.9	330	1679	123	41	0.128	0.205	4.2	8.5	11.6
LVW-B2	07/26/94	1150	2345-4	H	11.1	170	831	70	23	0.063	0.109	2.0	4.4	6.1
LVW-A	08/02/94	1210	2358-1	R	22.3	240	1684	47	25	0.107	0.235	5.9	9.3	9.6
LVW-B	08/02/94	1155	2358-2	R	22.7	300	1699	46	26	0.107	0.230	5.9	8.8	10.1
LVW-A	08/09/94	1235	2365-1	R	29.2	22000	1126	1095	370	0.193	1.429	2.9	3.9	7.2
LVW-B	08/09/94	1220	2365-2	R	31.8	22000	1072	1047	230	0.170	1.562	3.0	3.1	7.5
LVW-A	08/16/94	1320	2374-1	R	20.8	700	1563	111	39	0.116	0.415	4.0	12.6	11.8
LVW-B	08/16/94	1240	2374-2	R	24.4	240	1668	146	43	0.118	0.379	4.0	9.7	11.8
LVW-A	08/23/94	1210	2400-1	R	15.5	170	1651	54	38	0.091	0.307	3.3	11.9	12.2
LVW-B	08/23/94	1150	2400-2	R	16.6	1400	1693	62	41	0.125	0.320	3.3	11.5	13.1
LVW-A1	08/30/94	1550	2414-1	R	23.2	170	1767	92	46	0.113	0.414	4.5	14.0	11.7
LVW-A2	08/30/94	1550	2414-2	FD	22.8	170	1519	108	47	0.112	0.403	4.5	12.6	12.7
LVW-B1	08/30/94	1530	2414-3	R	23.8	130	1520	107	49	0.116	0.487	4.6	11.5	12.0
LVW-B2	08/30/94	1530	2414-4	H	12.8	130	743	55	30	0.067	0.243	2.2	6.0	6.2
LVW-A	09/06/94	1252	2420-1	R	17.7	220	1610	59	35	0.154	0.338	3.9	10.6	11.3
LVW-B	09/06/94	1238	2420-2	R	19.5	140	1662	53	28	0.154	0.307	4.2	9.6	11.6
LVW-A	09/13/94	1246	2426-1	R	16.1	50	1600	34	20	0.085	0.215	4.1	11.5	10.9
LVW-B	09/13/94	1229	2426-2	R	17.4	50	1625	33	18	0.084	0.181	4.5	9.5	11.4
LVW-A	09/20/94	1305	2436-1	R	28.9	50000	1477	81	43	0.190	0.301	4.1	9.5	11.5
LVW-B	09/20/94	1244	2436-2	R	32.8	13000	1547	63	35	0.178	0.323	4.4	7.8	12.2
LVW-A1	09/27/94	1254	2443-1	R	14.6	27	1612	41	25	0.132	0.226	3.2	11.3	11.9
LVW-A2	09/27/94	1254	2443-2	FD	16.7	240	1625	50	28	0.128	0.237	3.1	10.1	13.1
LVW-B1	09/27/94	1224	2443-3	R	20.5	110	1686	46	26	0.132	0.218	3.2	10.8	12.8
LVW-B2	09/27/94	1224	2443-4	H	5.6	50	882	14	12	0.065	0.114	1.6	5.1	6.4
LVW-A	10/11/94	1230	2460-1	R	24.5	27	1624	41	29	0.133	0.281	3.7	10.3	12.6
LVW-B	10/11/94	1210	2460-2	R	24.7	30	1670	58	30	0.136	0.286	3.8	10.8	12.5
LVW-A1	10/26/94	1300	2513-1	R	21.4	17	1670	28	9	0.148	0.258	4.0	11.9	12.2
LVW-A2	10/26/94	1300	2513-2	FD	21.5	14	1670	30	10	0.142	0.253	3.9	10.7	11.8
LVW-B1	10/26/94	1230	2513-3	R	22.0	80	1690	38	10	0.142	0.250	3.9	11.7	12.5
LVW-B2	10/26/94	1230	2513-4	H	9.7	23	834	27	8	0.073	0.133	2.0	5.5	6.3
LVW-A1	11/15/94	1310	2529-1	R	22.0	30	1739	87	43	0.266	0.450	3.2	10.7	14.2
LVW-A2	11/15/94	1310	2529-2	FD	29.0	8	1740	45	20	0.257	0.428	3.0	11.5	14.6
LVW-B1	11/15/94	1245	2529-3	R	18.8	13	1787	25	17	0.268	0.393	3.2	11.6	14.2
LVW-B2	11/15/94	1245	2529-4	H	15.9	4	951	16	10	0.134	0.197	1.6	5.5	8.7
LVW-A1	12/13/94	1320	2604-1	R	32.0	23	1765	27	15	0.430	0.563	9.2	12.8	11.2
LVW-A2	12/13/94	1320	2604-2	FD	32.0	26	1749	22	15	0.418	0.580	9.0	12.2	10.9
LVW-B1	12/13/94	1300	2604-3	R	30.0	30	1831	26	18	0.395	0.479	8.2	11.5	10.5
LVW-B2	12/13/94	1300	2604-4	H	13.3	13	941	17	10	0.194	0.248	4.0	5.6	6.1

R=Routine Sample F=Flood Sample FD=Field Duplicate Sample H=Half Dilution Sample